PAVING US-BANK STADIUM Real World Paving Never Changes

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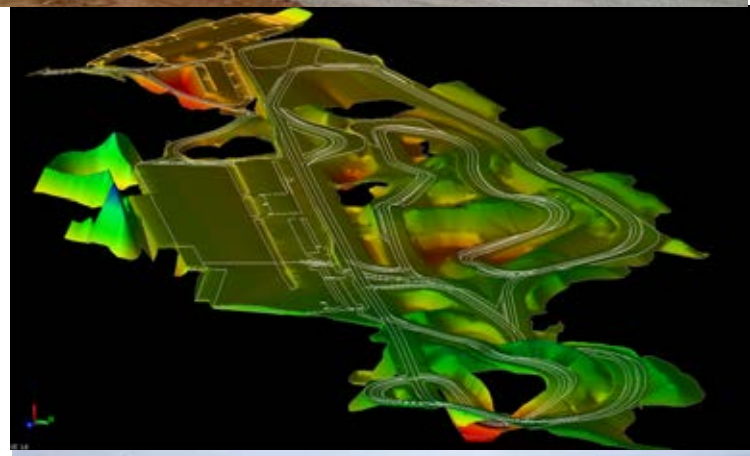
OVERVIEW

- Introduction Video
- Why 3-D
- Paving Fundamentals
- 3-D Capabilities
- Project Pre-Planning
- 3-D The Hardware
- Grading/Surface Prep
- Training
- Paving
- Results
- Lessons Learned

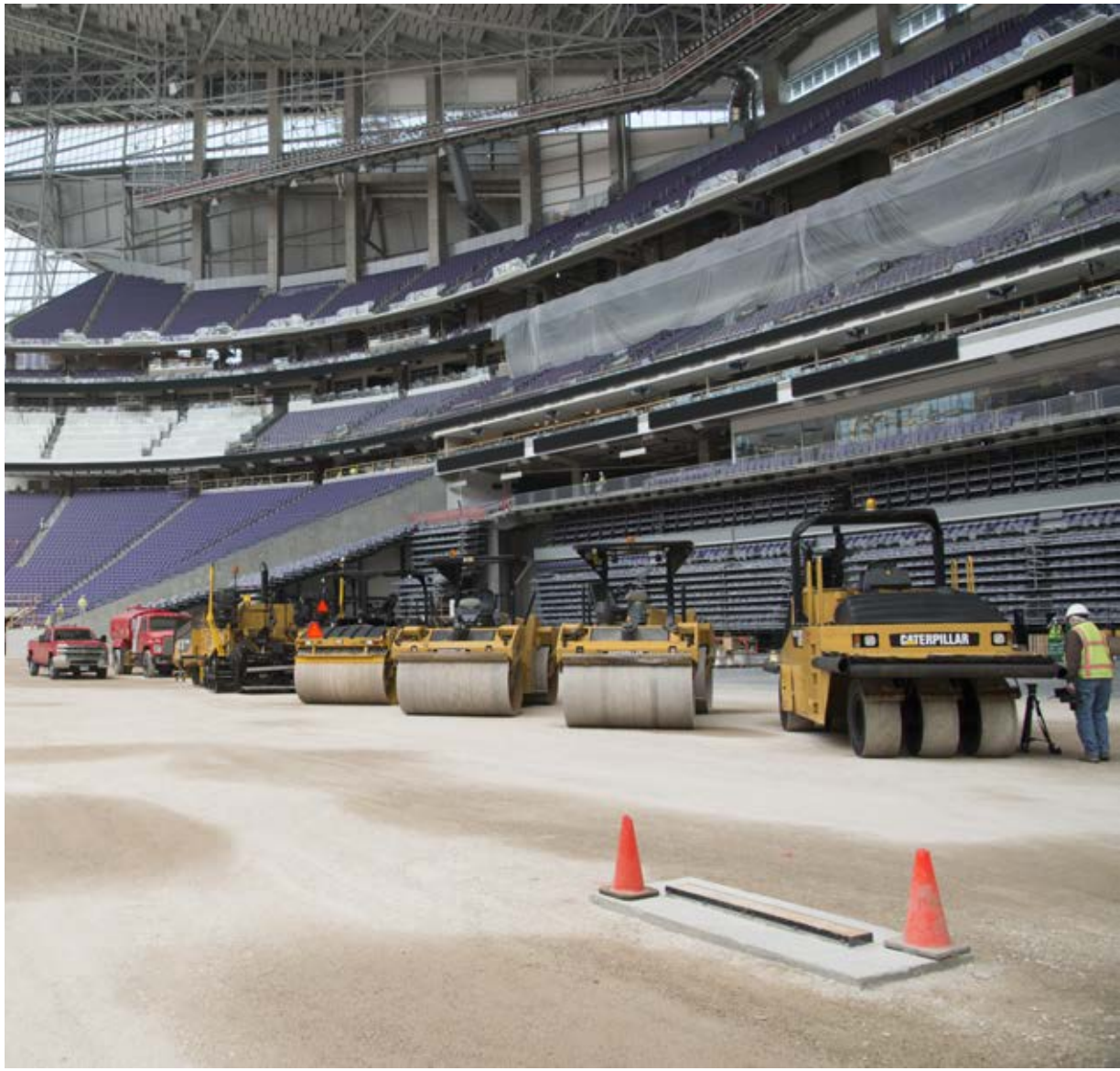
3D PAVING

- Precise material lay down
  - Precise control of material – material savings
    - Precise control of elevations and profile
    - Accurate within 1/24”–1/8” (1-3 mm)
  - Less chance of operator error with complex designs
    - Transitions
    - Super-elevated curves
    - Frequently changing cross slopes
- Smoothness
  - 3D equipment and controls facilitates less screed adjustments delivering the smoothest application of asphalt.
  - Maintain production rate – No stopping/starting



ADVANTAGES OF 3D PAVING

- Achieve the highest accuracy and smoothness levels
  - Better material management/yields
- Eliminate the stringlines:
  - Reduce staking labor, downtime and errors
  - Reduce costly rework
  - Finish the project faster
- Pave complex designs
- Use a “PCS Uncompacted Design” to help differential compaction issues



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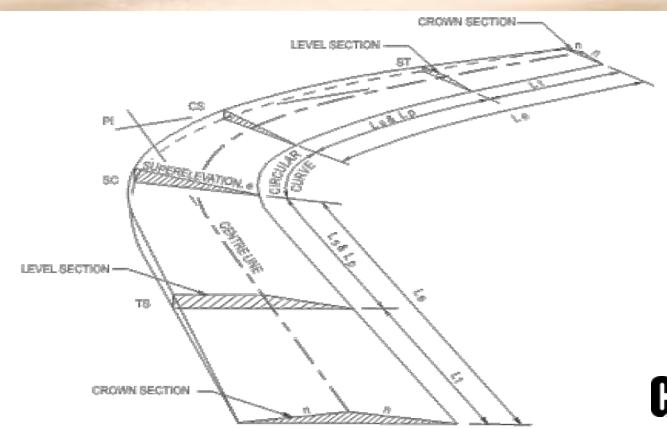
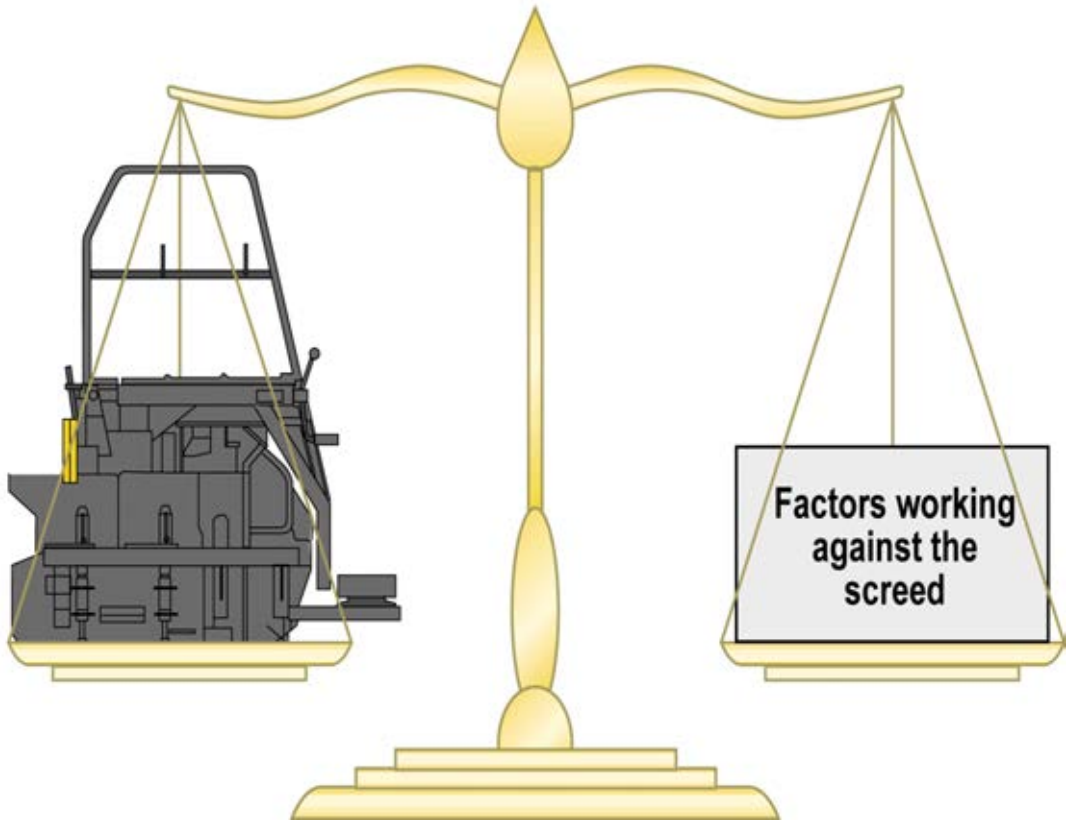
WHAT ARE THE APPLICATIONS OF 3D PAVING?

- Any project where a contractor uses stringline or wire for elevation grade
- Variable depth and slope paving applications
  - Airports, roads and commercial surfaces
  - Base material (P209, gravel, etc…)
  - Asphalt
  - Roller Compacted Concrete (RCC)
  - Cement Treated Base (CTB)
  - US Bank Stadium!
- Any paving project that has a 3-D plan



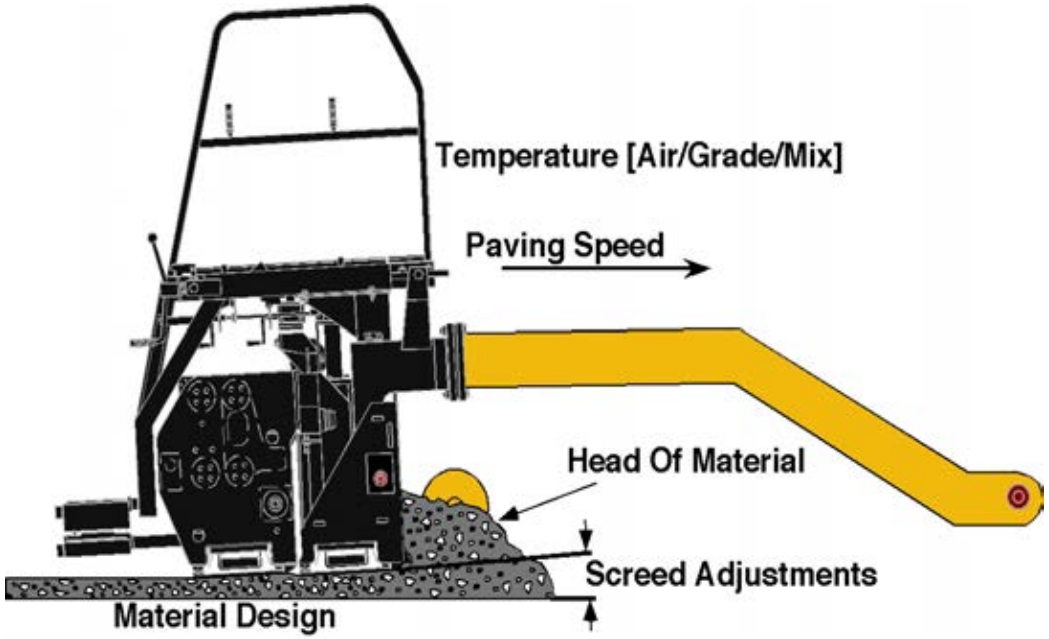
UNDERSTANDING THE PAVER



Free-Floating Screed

- Screed position determines mat thickness
- Screed position is constant as long as all factors remain constant

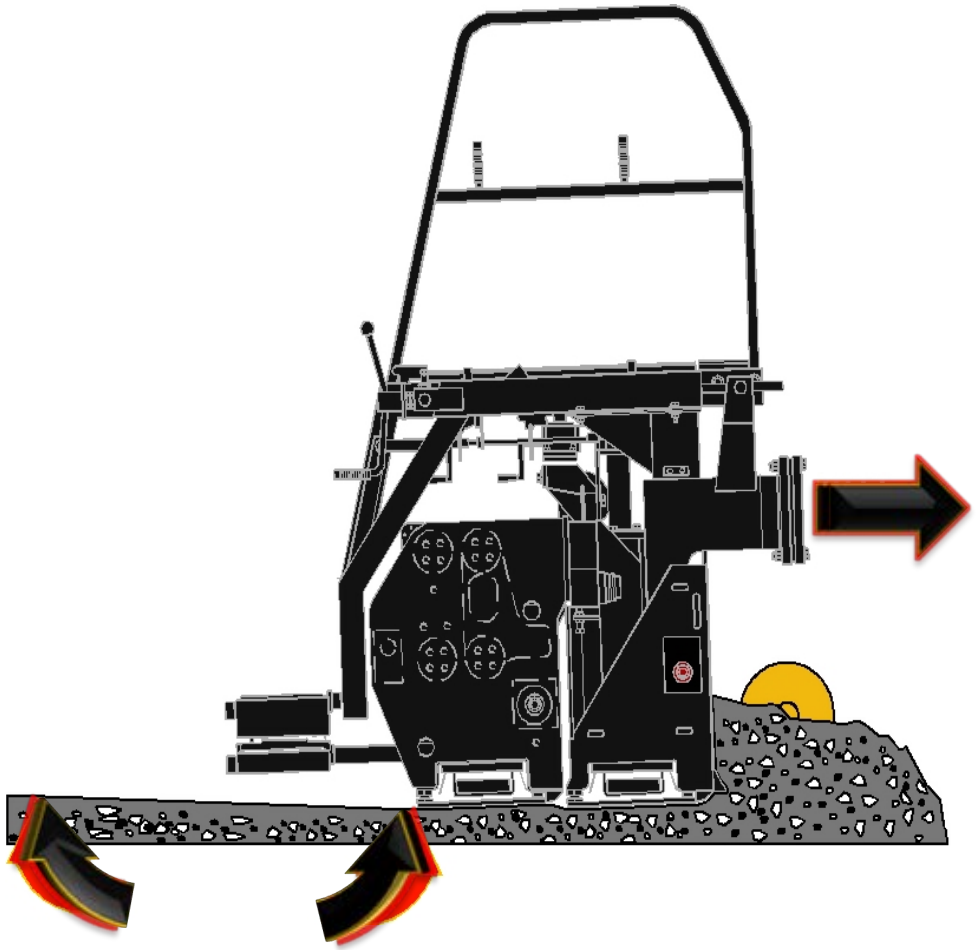
UNDERSTANDING THE PAVER



Factors Affecting the Screed

- Paving speed
- Head of material
- Screed adjustments
- Mix design
- Mix temperature
- Air temperature
- Grade temperature

FACTORS AFFECTING SCREED



Increased Speed

- Shear factor decreases
- Depth decreases

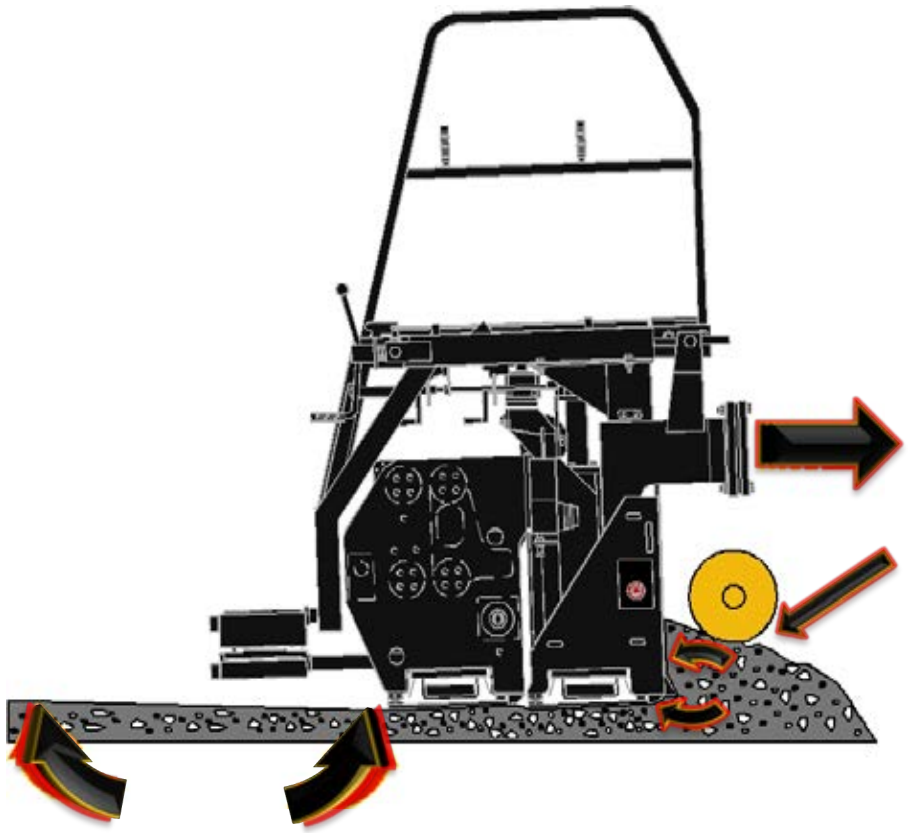
Decreased Speed

- Shear factor increases
- Depth increases
- Amount of depth change varies with amount of speed change
- Mix design also affects shear factor

FACTORS AFFECTING SCREED

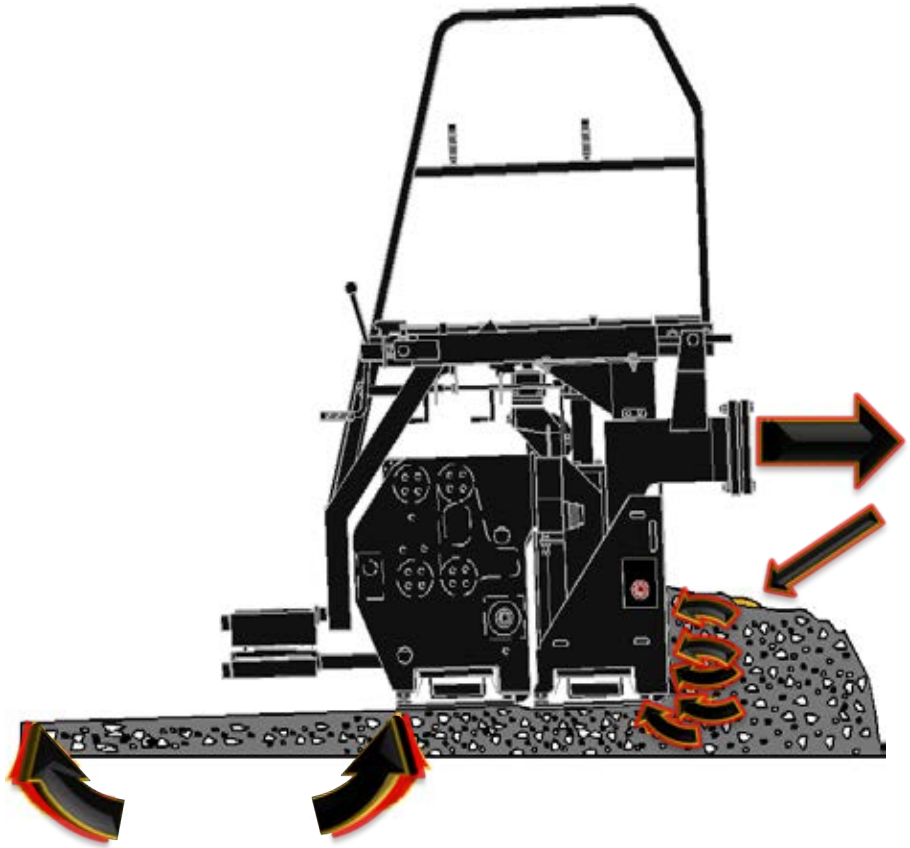
Head of Material Decreased

- Resistance decreased
- Depth decreases



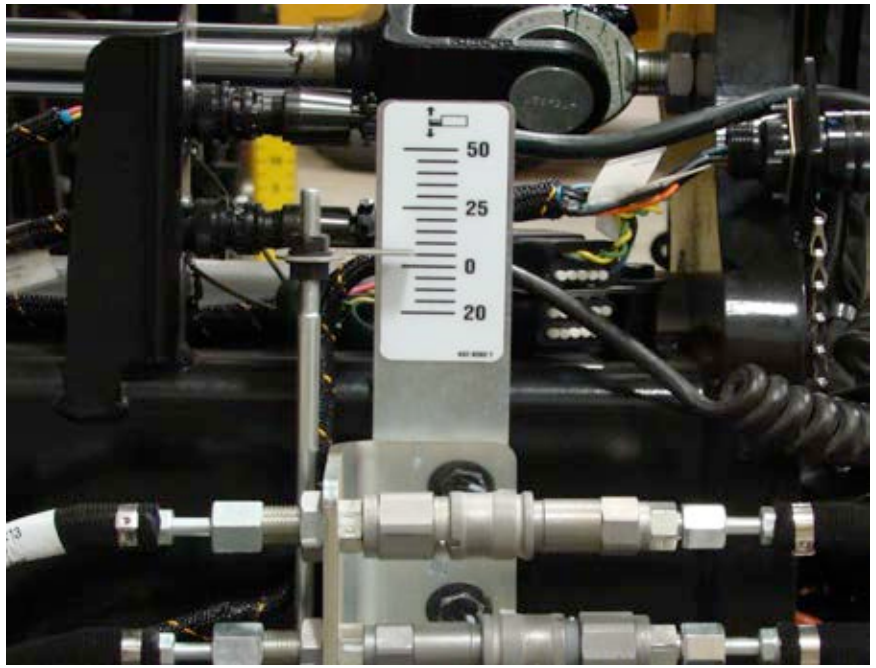
Head of Material Increased

- Resistance increased
- Depth increases



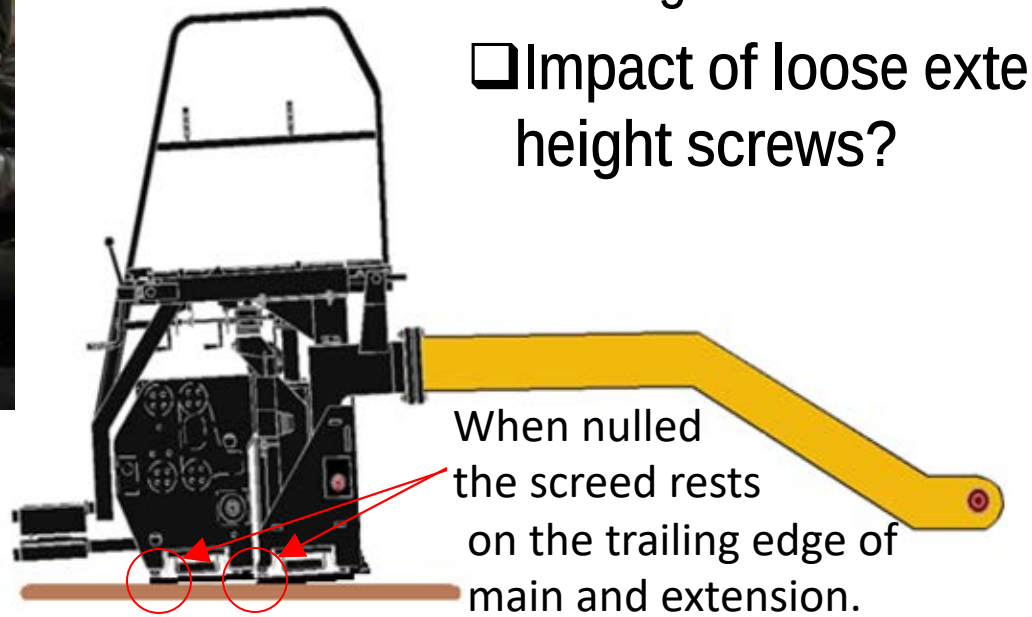
FACTORS AFFECTING SCREED

CAT PAVING BY THE NUMBERS

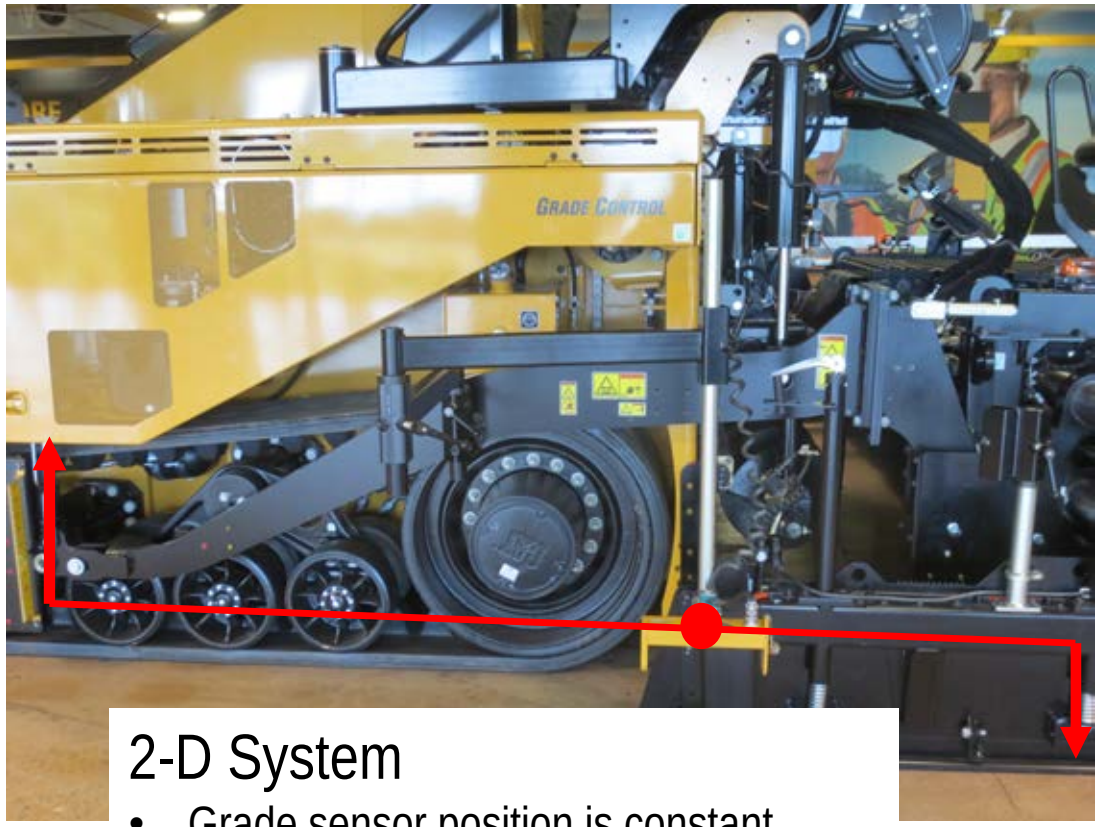


STEP 5

- ✓Set Extender height
- ❑5mm (3/16”) above
- ❑Setting extender height will set angle of attack
- ❑Impact of loose extender height screws?

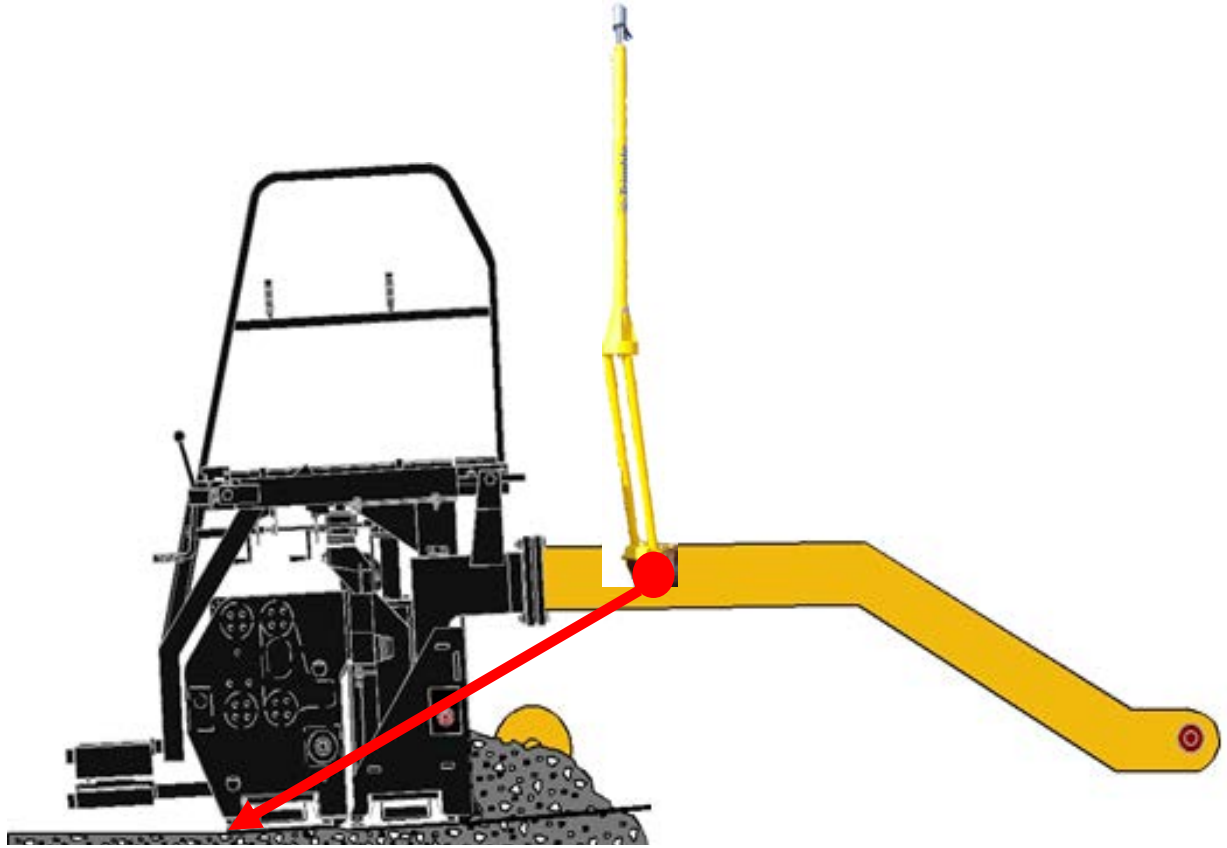


3-D CAPABILITIES



2-D System

- Grade sensor position is constant
- Grade sensor is like a fixed pivot point
- System forces change (head of material, paving speed, etc…
  - Screed drops – tow point raises
  - Screed raises – tow point drops



3-D System

- Tow arm slope sensor is used to determine the position of the trailing edge of the screed
- System forces change (head of material, paving speed, etc…
  - Screed drops – tow point raises to maintain screed position (3-D grade sensor position is not fixed)
  - Screed raises – tow point drops to maintain screed position

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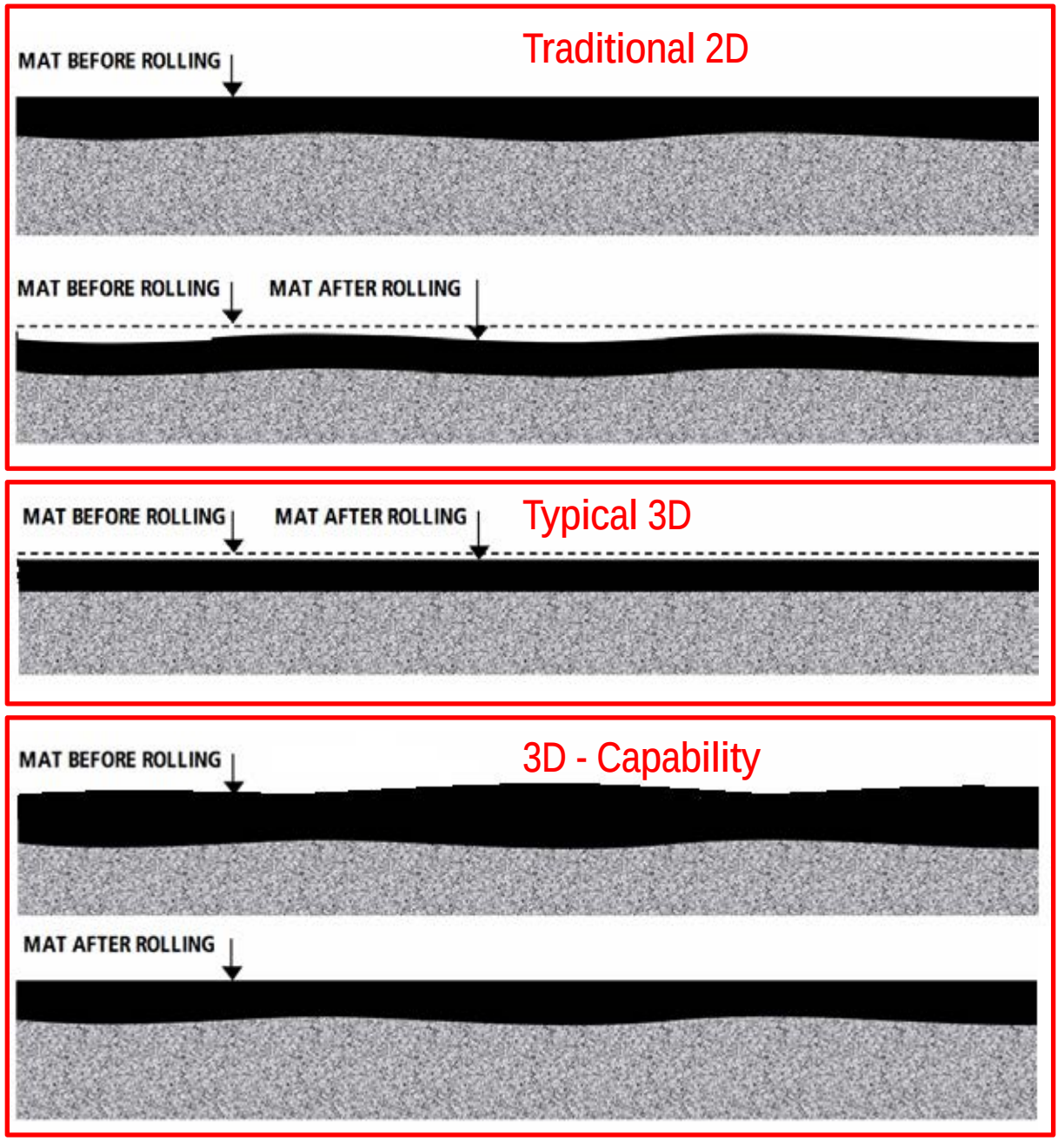
MORE 3-D CAPABILITIES

- "Top Down" approach rather than "Bottom Up"
  - Aiming for target 3D design elevation rather than targeting thickness from a ground reference



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PROJECT SCOPE

- Asphalt pave the playing surface of US Bank Stadium within extremely tight tolerance and time constraints
- Three days to pave two lifts of 2 ½” first lift and 2” second lift

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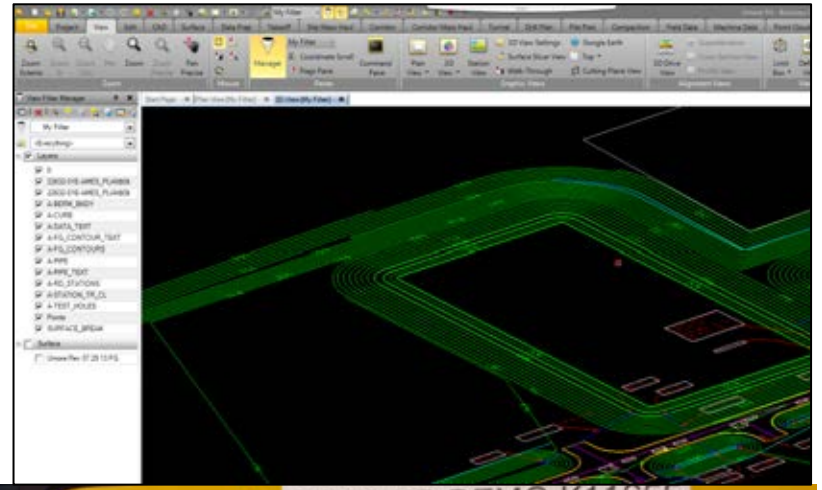
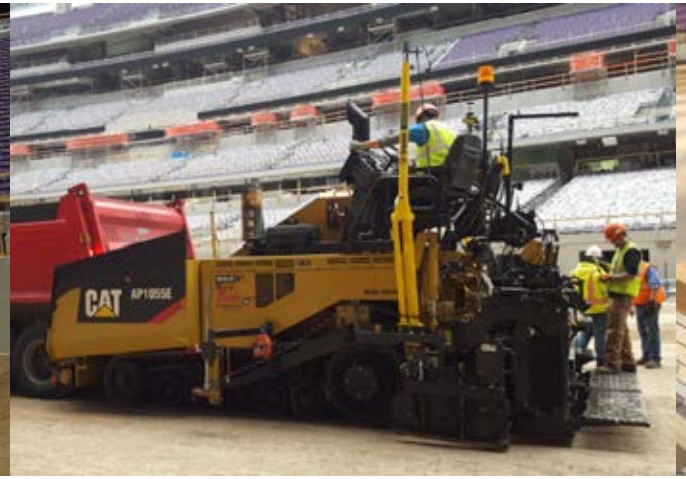
PROJECT PRE-PLANNING

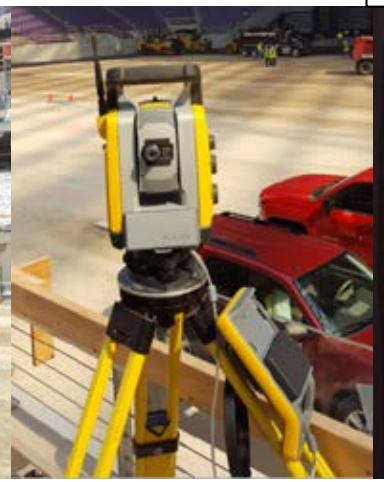
- Project bid with plan to use concrete, but there was also an alternate option of asphalt
- Project bid tolerance of ¼” per 10’ grid
- February 2016 – Park earned job to pave stadium floor, no clear tolerance defined; idea of 3D presented but not initially chosen
- Early March 2016 – No 3D; contractor will use traditional 2D method to pave floor
- Planned to use 3D on blade and sonic tracers on paver
- March 20 - Park meets with NFL, learning there will be no option to remove & replace or mill if layed incorrectly. Tolerance finally defined: 10’x10’ grid with no area outside 1/8” tolerance
- March 22 - Parts ordered for UTS 3D system for paver
- March 30 – 3D install complete, customer picked up to adjust
- April 6-8 – UTS Grading with grader
- April 13 – First lift of paving
- April 15 – Second (final) lift of paving

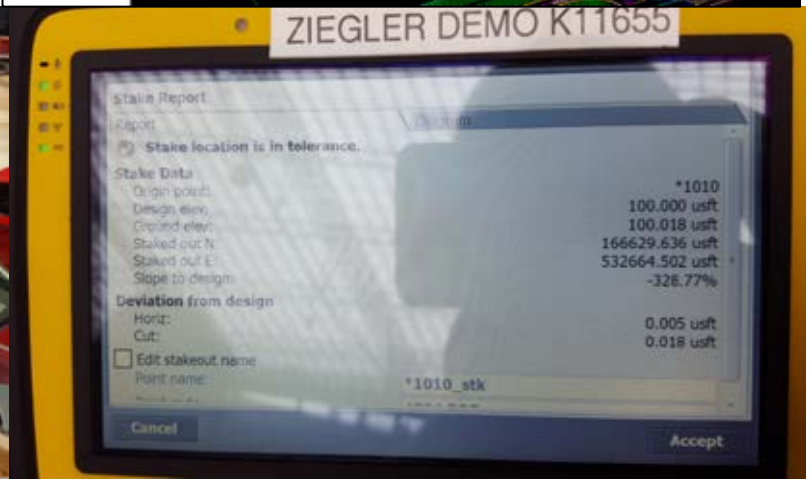
TECHNOLOGY EQUIPMENT USED

- Caterpillar 160M Grader
- Trimble GCS900 3D UTS System
- Caterpillar AP1055E Paver with factory Cat Grade & Slope
- Trimble PCS900 3D UTS System
- Trimble SPS930 Universal Total Station (2)
- Trimble Site Tablet with SCS900 Software
- Trimble Business Center – File management and surface creation



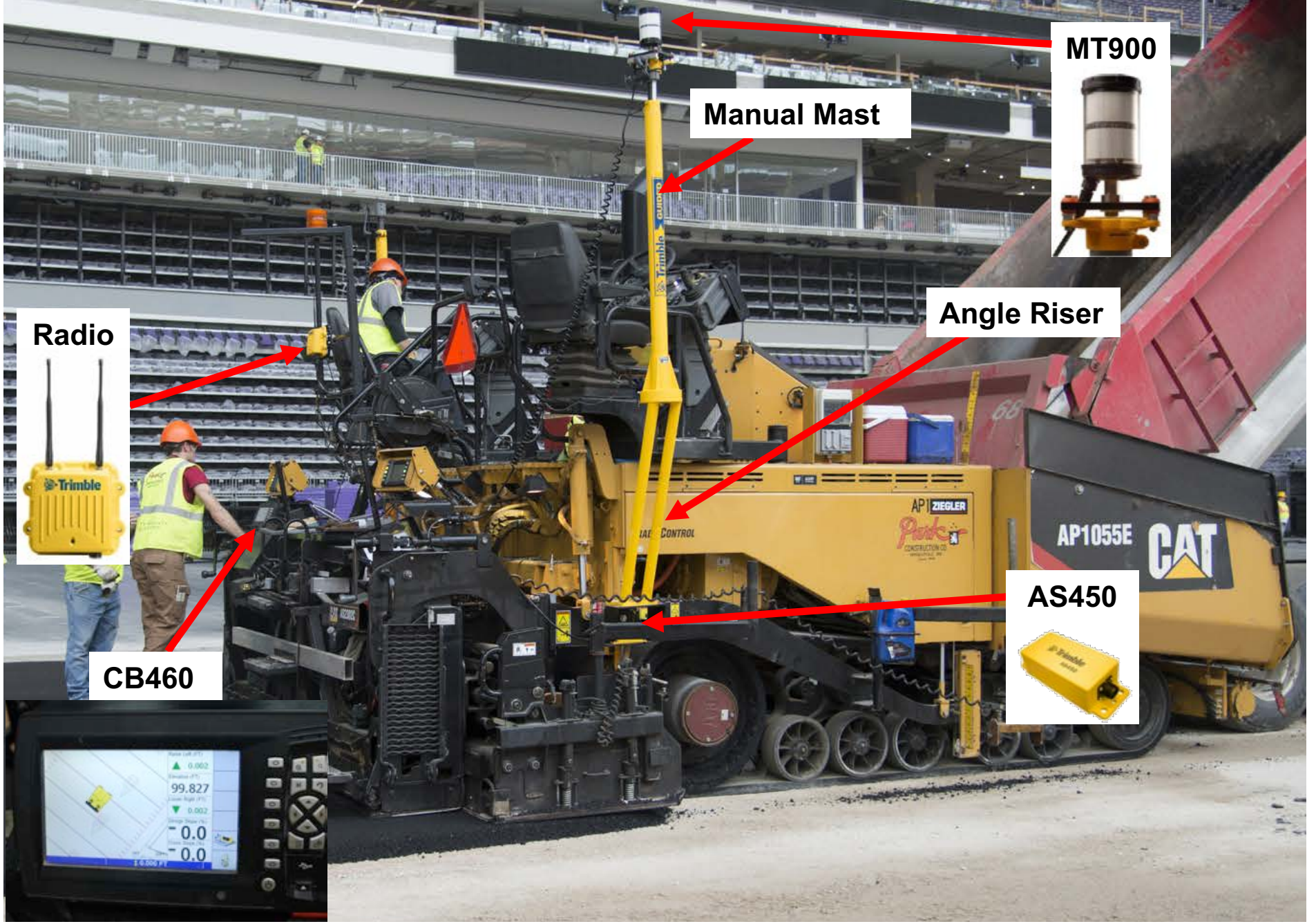






HARDWARE

SPS930



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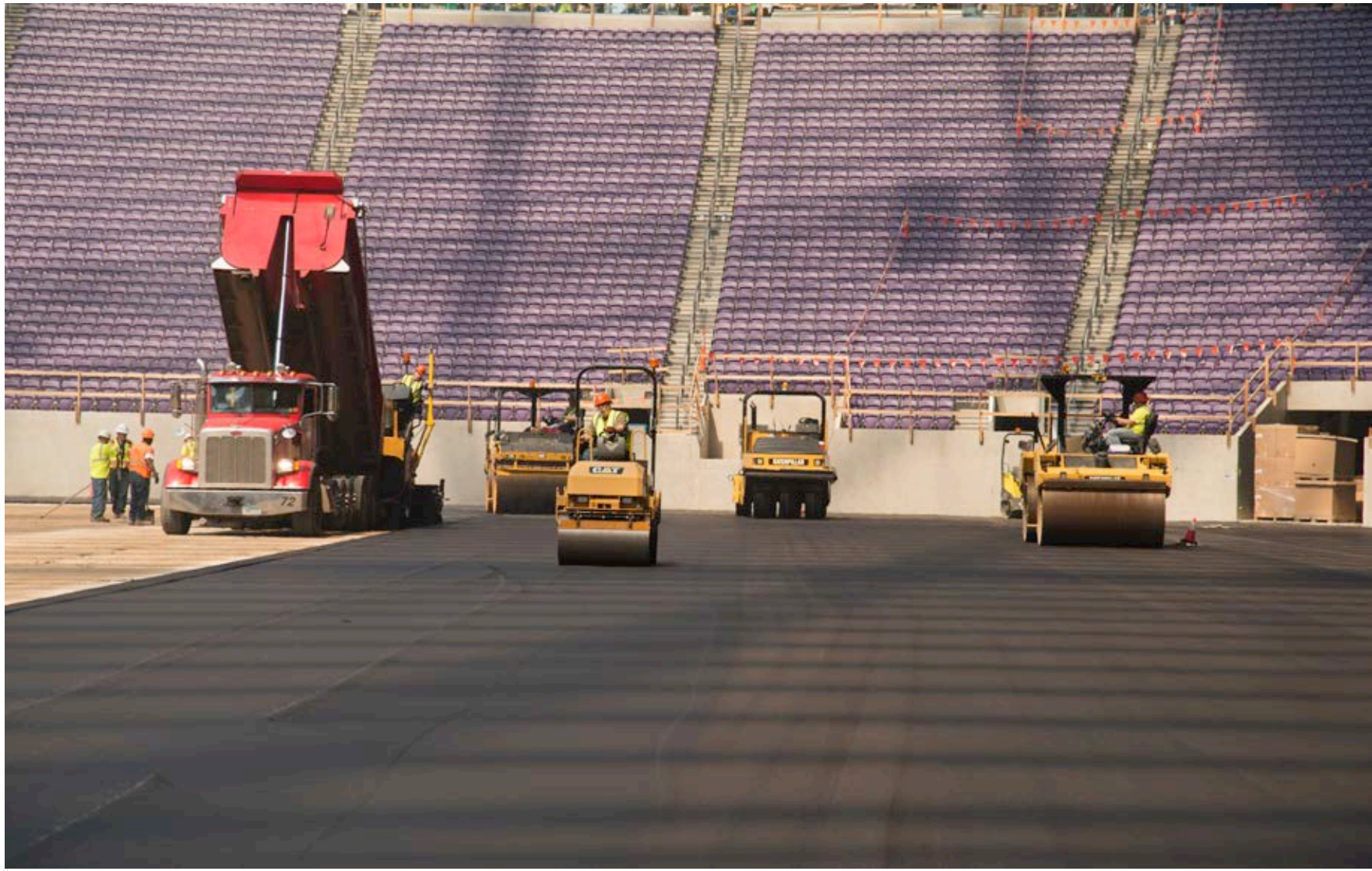
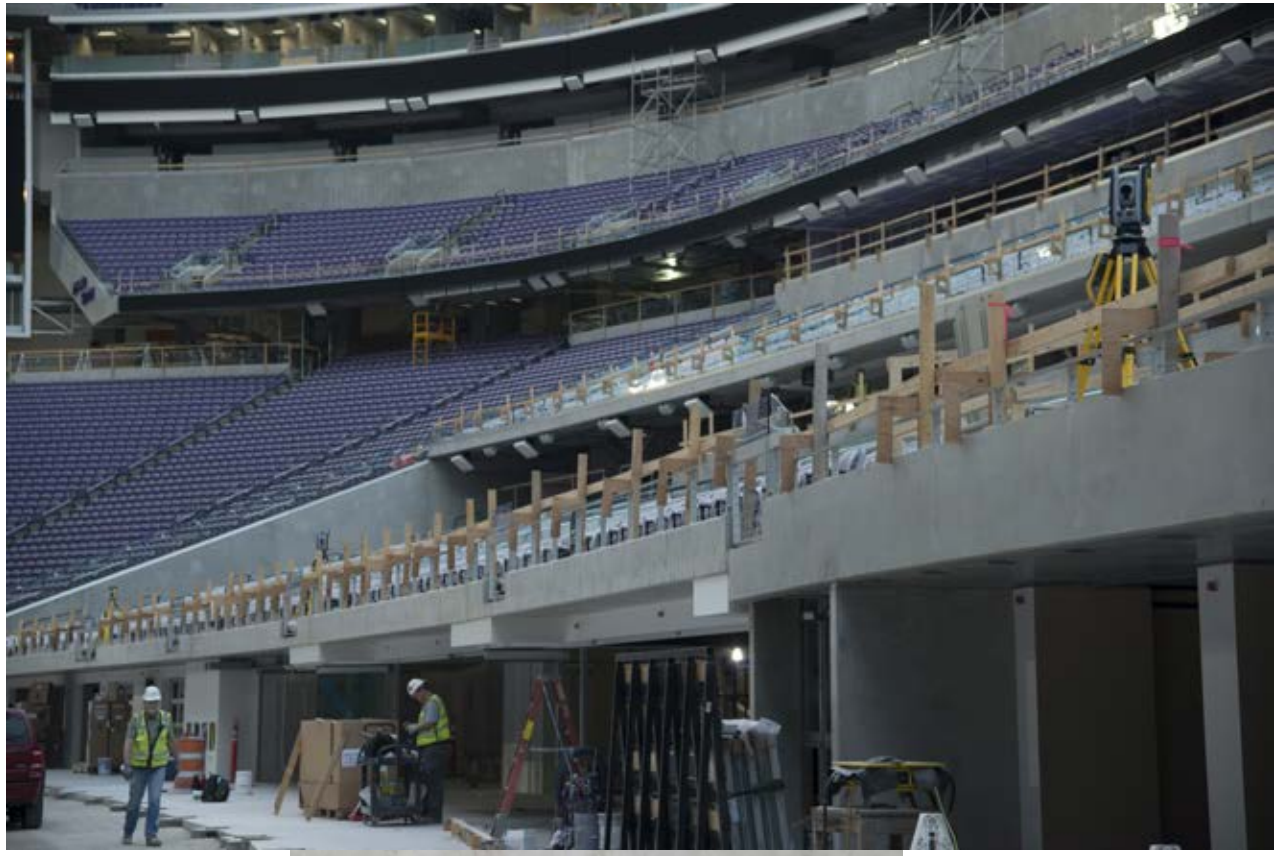
COMPACTION TRAIN

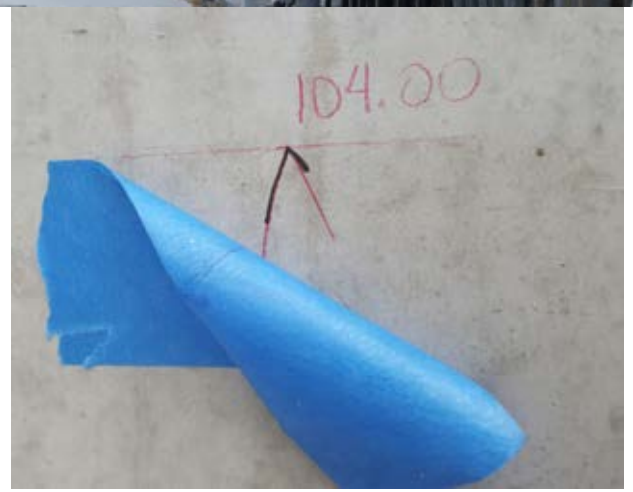
- CB66B – 84” Breakdown
- PS360C - Intermediate
- CB64 – 84” Finish
- CB24B – Finish roller
- Wacker RD12 –Finish roller



GRADING/SURFACE PREP

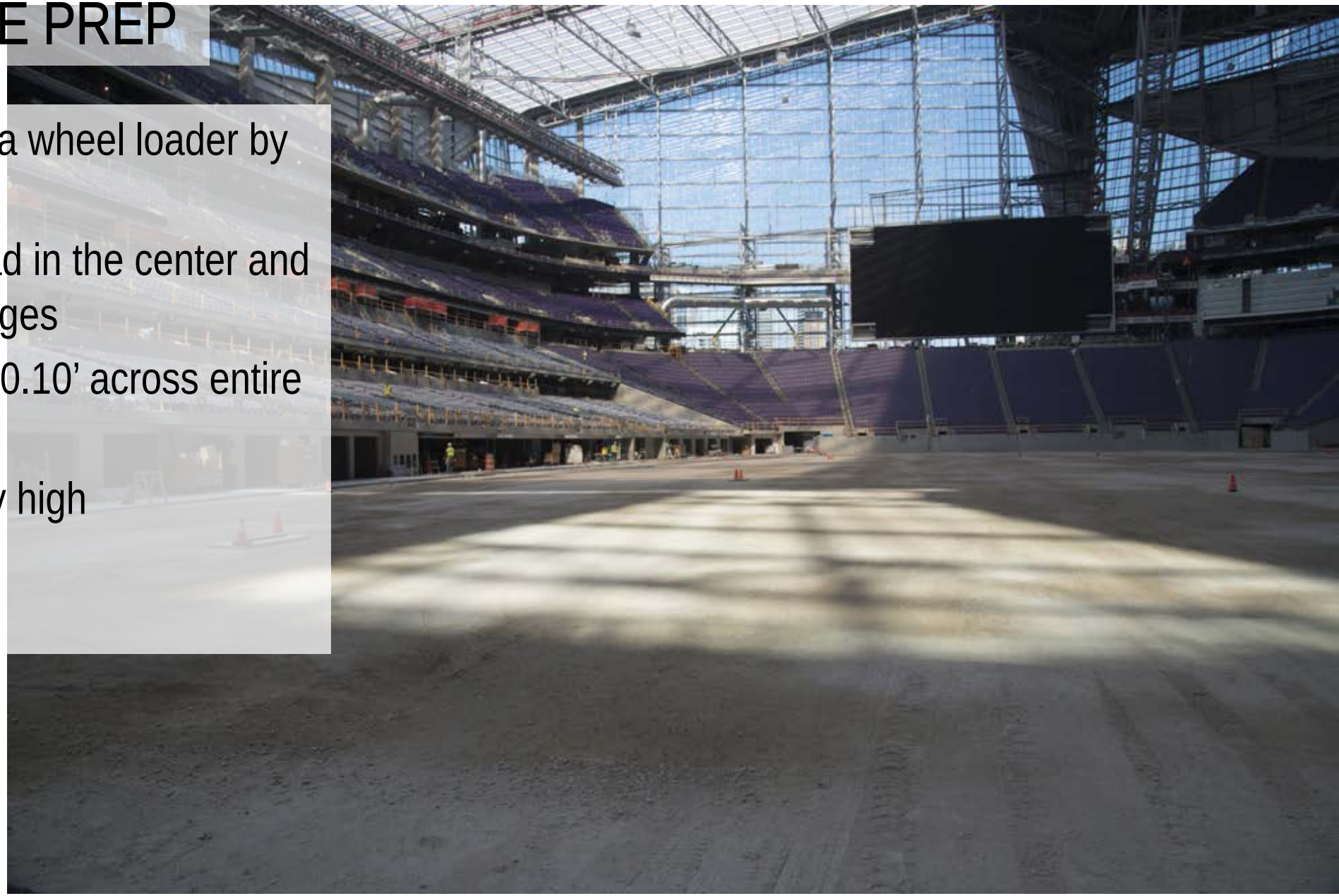
- Before grading could begin, must verify control point accuracy
- Tolerance of setup must be less than half of expected accuracy
- 1/8” final tolerance required max of 1/16” (0.005’) variance in control
- Minimal points provided on floor; minimal options for total station setup position
  - Two ground points with x, y, z defined
  - Verified elevation marks around wall





GRADING/SURFACE PREP

- Subgrade laid with a wheel loader by different contractor
  - Started with a pad in the center and worked out to edges
  - Subgrade within 0.10’ across entire field
  - Ended up slightly high



GRADING/SURFACE PREP

- UTS Graded with 160M
  - Base was hard and very difficult to manipulate
  - Required serrated cutting edges to loosen existing material
  - Had to loosen at least 1 ½” deep
  - Graded out 4 or 5 truck loads of base material, about ¼” average over entire field
  - Would have been better left 0.2-0.3’ low to allow easier grading
  - Should have done a TOPO on the base to load into Trimble Business Center and plan for compaction

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TRAINING

- Paver install completed at Ziegler Cat
- Final calibration/measurements performed on site
  - Mast position relative to trailing edge of screed measured
  - Slope sensors calibrated

TRAINING

- Ziegler was then brought to site to train customer on 3D system
- Verified machine is operating properly and customer is comfortable with process by paving sand
- Stressed importance of following paver manufacturer's best practices (Paving by the Numbers)
- 3D will not eliminate poor paving practices

KEEPING DOWN THE DUST

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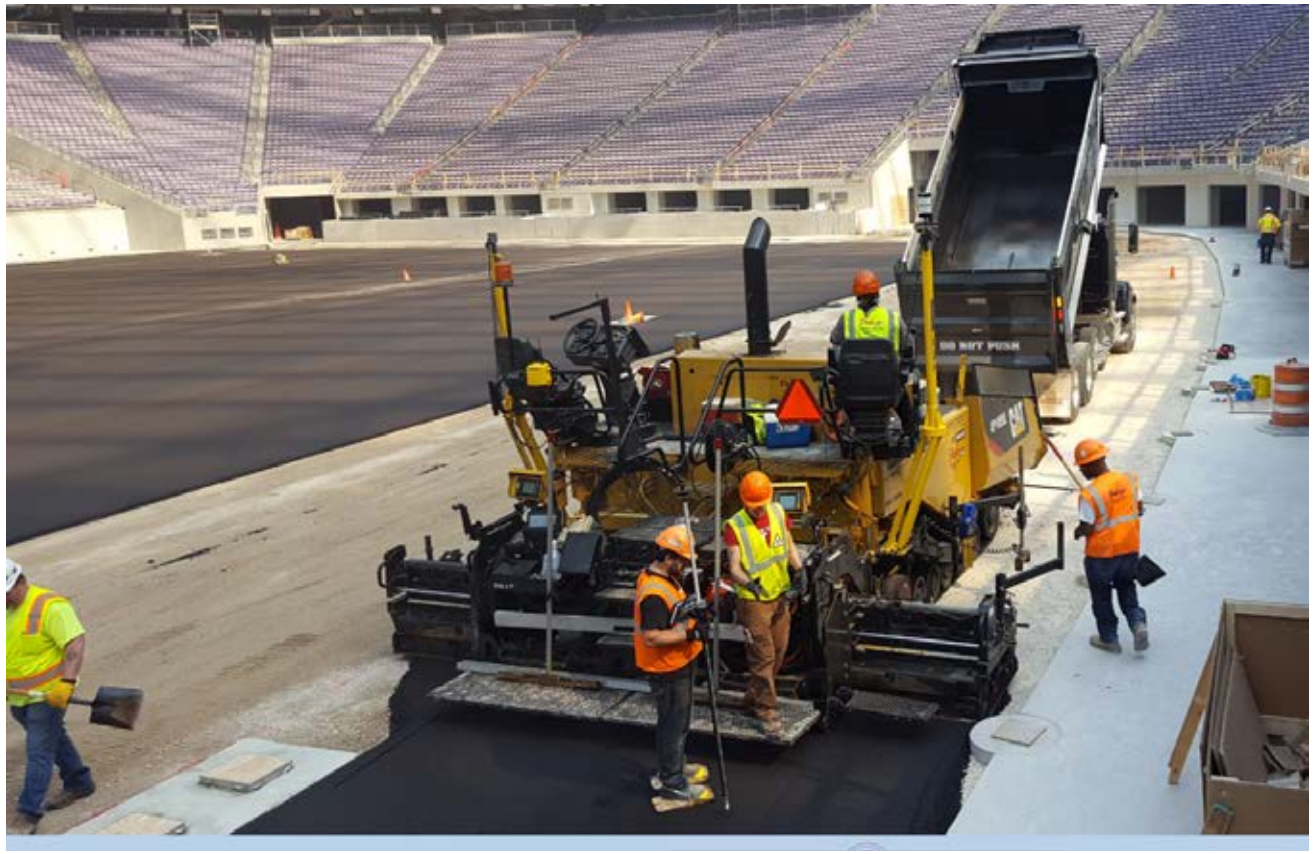
PAVING SCHEDULE

- April 13 – 1st lift paved
- April 14 – Review of 1st lift; Surface TOPO
- April 15 – Final lift
- April 18 – Field tested by NFL turf contractor

PAVING 1ST LIFT

Challenges:

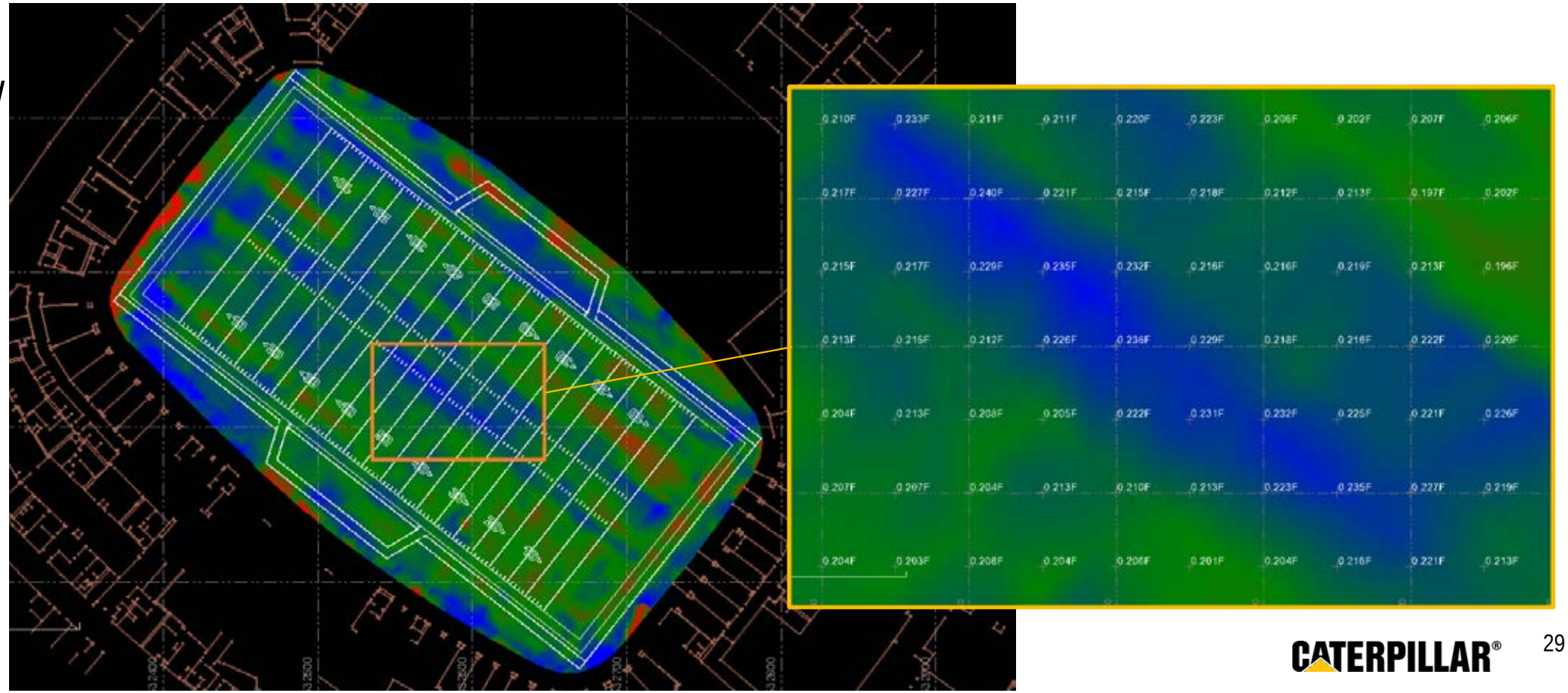
- Screed diving on starts
  - Angle of attack – Paving by the #'s
- Screed raising/lowering when extenders moved in/out
  - Changing head of material
- Trucks backing into paver
- Truck pushing out of the paver
- Slope Sensor calibration not holding
  - Inconsistent "3D Slope" side
- End gates not floating
  - Gouged surface



PAVING THE BASE - RESULTS

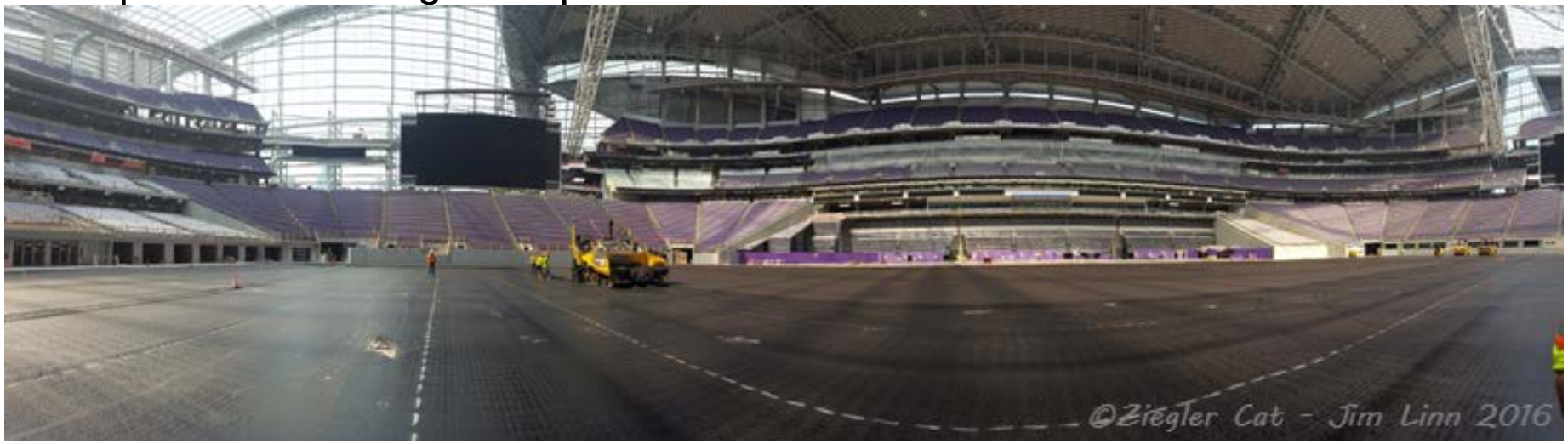
Topo readings taken behind screed

- Readings are in feet to base level elevation
- Compacted elevation of the first lift @ 99.825’
- Blue = low
- ½” - ¾” low



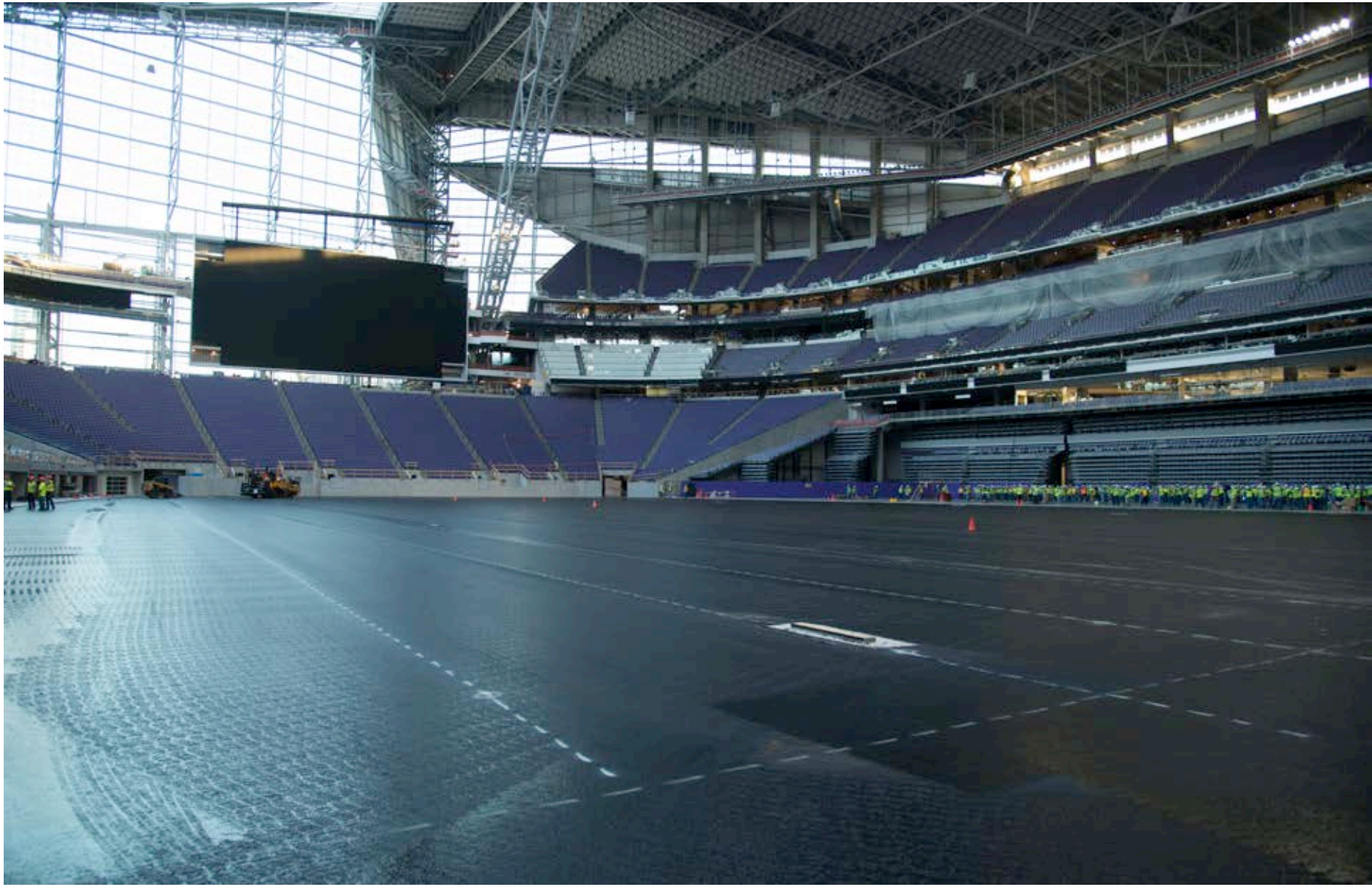
PAVING SURFACE REVIEW

- Imperfections in 1st lift jeopardize success of project
- Full as-built TOPO taken by contractor
- TOPO loaded into Trimble Business Center; Un-compacted Surface created
  - Pave low spots thicker and high spots thinner to achieve desired surface elevation after roll-down
  - Paver driven in same tracks as lift one, system anticipates “thick” areas and raises tow points prior to reaching this spot to achieve finish elevation



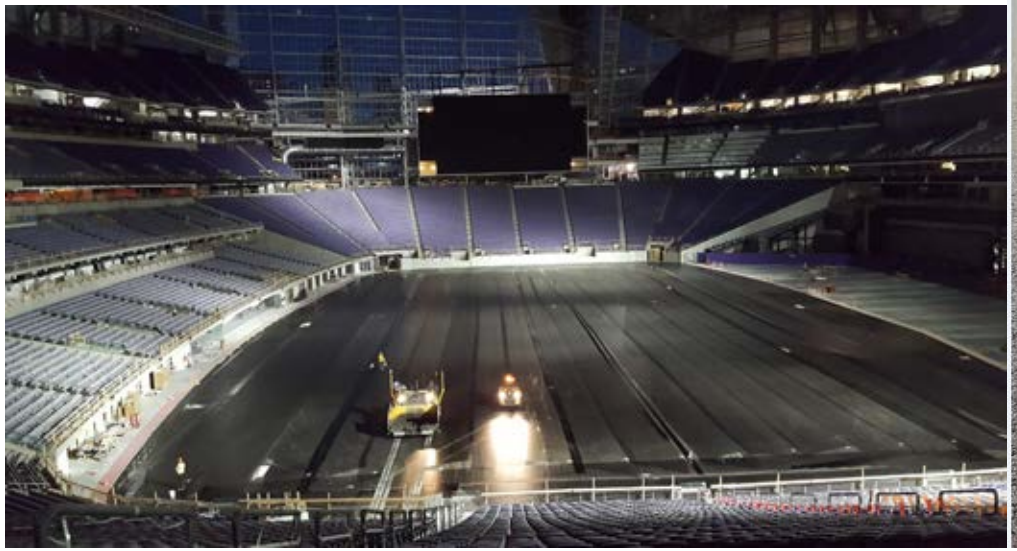
DAY 2 – FINAL LIFT

- Tack Coat
- Painted Pass Marks to fully utilize uncompacted surface capability



PAVING FINAL LIFT

- CAT Paving emphasizes Paving by the Numbers; screed stabilizes
- Un-compacted Surface works perfectly, corrects imperfections from lift one after rolldown; confirmed by Park Construction Technology Champion with Rover
- 18 hour day paving ends with completely paved stadium floor



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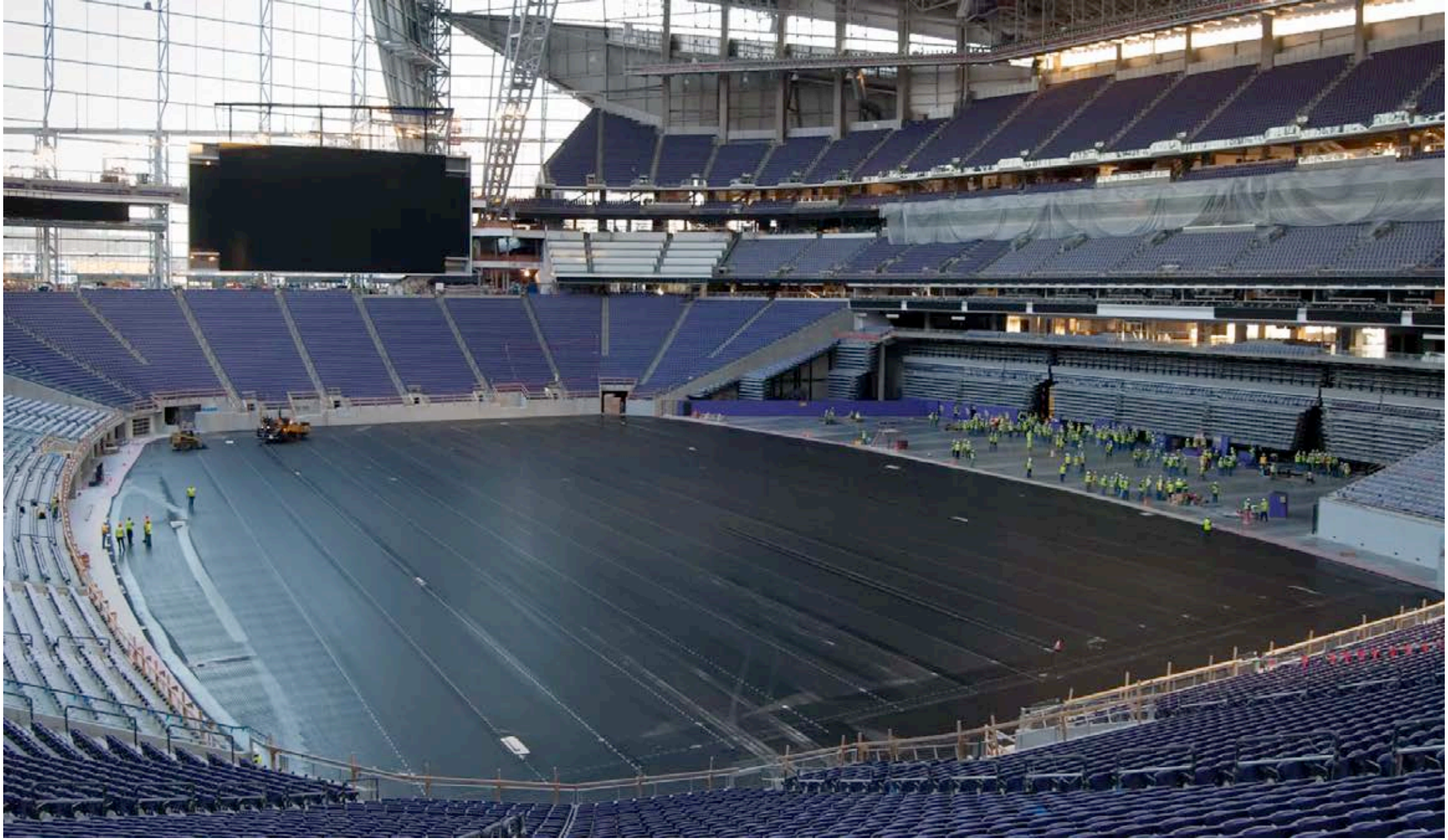
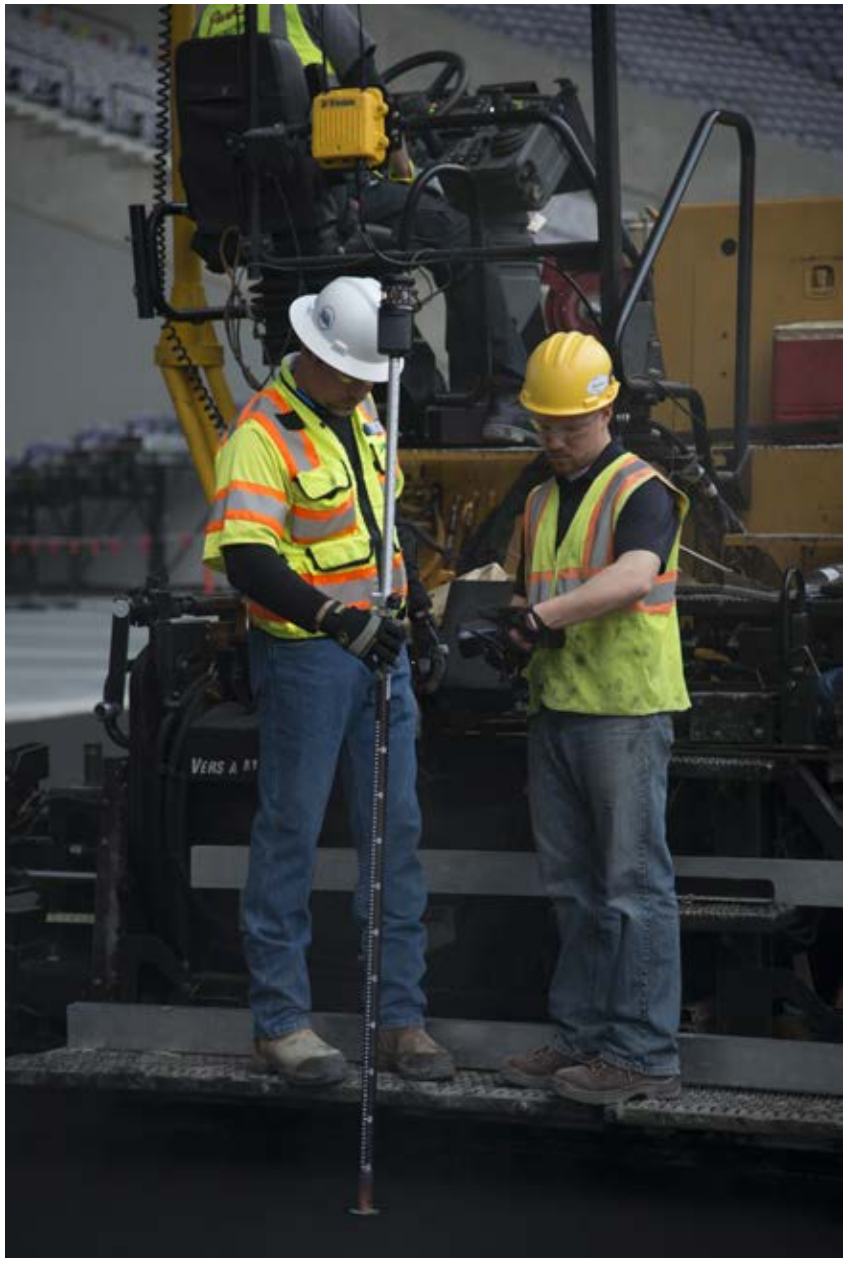
DAY 2 – FINAL LIFT

- Cleaning truck beds in the tunnel
- Day 1, trucks had been blocking line of sight when cleaning out



TESTING

- Park Construction received outstanding feedback on the accuracy of the pavement
- No 10x10’ grid could be found out of tolerance
  - 10’ straight edge, a quarter could not fit underneath anywhere
  - The overlay company went N-S and E-W and found less than 1/32” over any 10 ft length

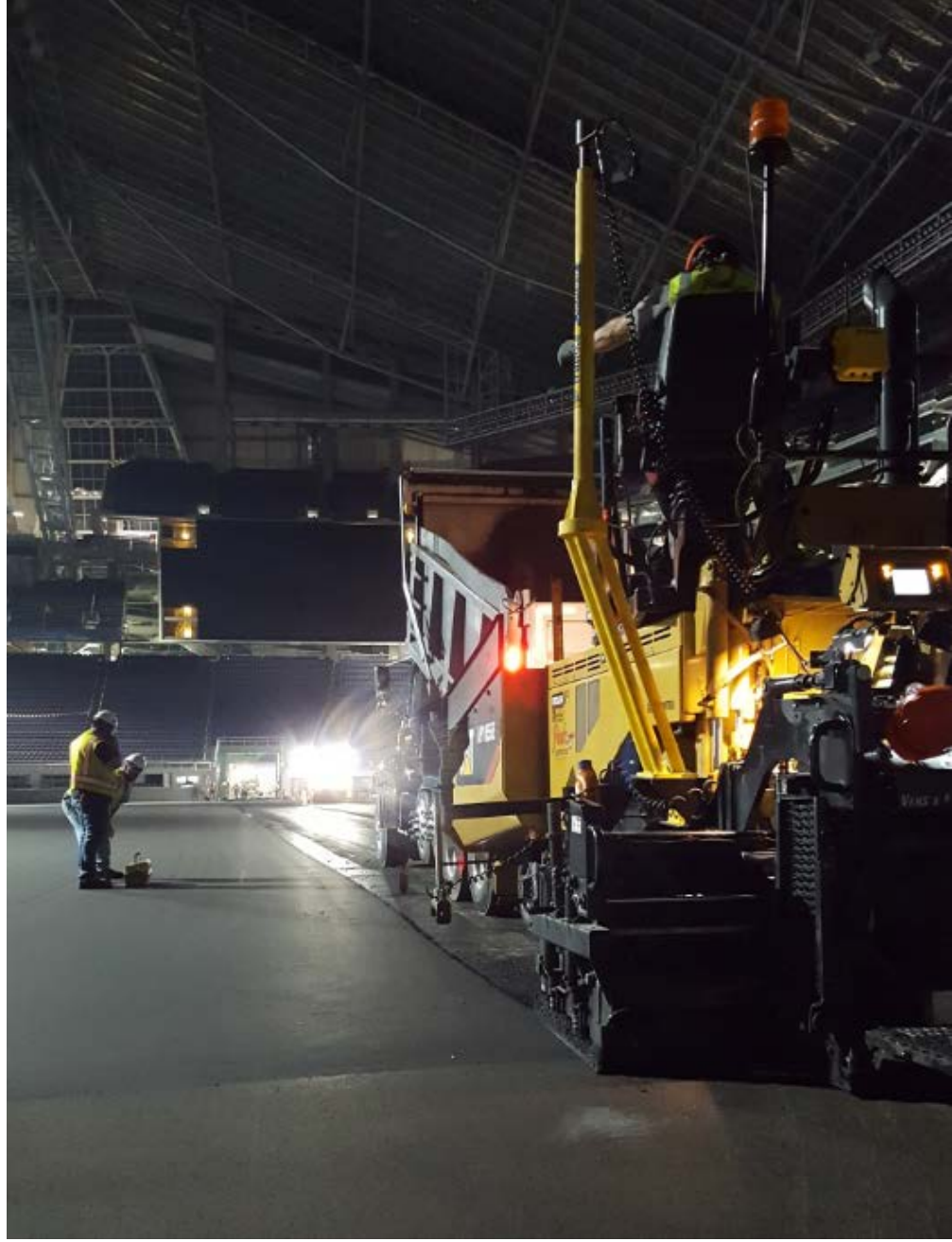


LESSONS LEARNED

- Paving fundamentals are always critical
- It takes a team to complete a successful project
- Planning logistics details is worth every second
- Have backup plans in place for equipment & process
- Sensor placement with line of sight un-obstructed
- Utilize all the capabilities of the system – allow for compaction
- Learn from mistakes and plan for success

WHAT IMPRESSES ME MOST

- Park stuck with the system after the first day, it would have been easy to back away and say we can do better with 2-D.



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ACKNOWLEDGEMENTS

- Park Construction
- Trimble Navigation
- Special Thanks to Ziegler and Jim Linn

Thank you for building a great infrastructure that enables a better life for all.

QUESTIONS OR COMMENTS?